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ABSTRACT

This paper describes an adaptation of Dyer's regression model that uses data on individual students in an attempt to isolate the influence of different schools on variations in student achievement growth. This procedure involves comparing the results of a multiple regression analysis of individual student achievement scores and several categorically coded background variables with the results of a similar regression that also included "school attended" as a categorical predictor variable. This procedure was used to analyze data for cohort samples of 1,308 sixth-grade students and 1,255 seventh-grade students from four middle schools in a medium-sized school district. Results of the analysis indicate a significant variation in the contribution of different schools to growth in student achievement. (Author/JG)

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EXAMINING SCHOOL EFFECTS ON ACHIEVEMENT:

A CONCEPTUAL MODEL AND AN EXAMPLE

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In the educational world of the mid 1970s school administrators find themselves confronting a question that touches the very core of educational accountability. That question involves which, if any, of the schools at a particular level in a school district is doing an exceptionally good or exceptionally poor job of improving the achievement of its children. Typically, administrators answer this question using "data" such as intuition, general feelings about school morale, attendance and disturbance reports, as well as test scores. Much of this information, although valuable, lacks the objectivity required to serve as criteria for decisions regarding program or personnel changes. Disparate conditions of students' backgrounds and entering abilities from school to school further cloud the comparison base. It is well known, of course, that factors such as socioeconomic status, general intelligence, and sex, among others, have a differential effect on learning (13,4). Therefore, these factors cannot be overlooked when considering a difference in achievement between the products of two schools regardless of the objectivity of the data used in this comparison.

An accountability model introduced by Dyer (2) proposes a statistical technique to examine school achievement differences and include allowances for differing background or "hard-to-change" input conditions. This model uses a

regression analysis to generate a prediction of student achievement that could be expected, considering prevailing levels of previous achievement, intelligence, socioeconomic conditions, and other pertinent variables. Although specifically devised to make descriptive comparisons among schools, Dyer's model and others based on it (10, 11) only address the question: Which school is doing better or poorer than can be expected? Schools are not compared directly with each other but to an intermediate criterion formed by the regression equation.

Dyer's model proposes that achievement data on both the fundamental hard-to-change variables and the output measures (usually achievement scores) be collected in all the schools at a given level in a school system. Data on the same pupils on the same output measures are then collected again two or three years later. An equation for prediction is calculated from the regression of the later year's average performance scores for each school on the averages of the earlier year's performance scores and hard-to-change variables. Performance for an individual school, as predicted by this formula, is then plotted against its actual performance in a particular subject matter area. The discrepancy (residual) between predicted and actual performance is scaled and called its School Effectiveness Index (SEI). A school with a positive SEI would be doing better than one with a lower SEI, when the hard-to-change differences are controlled.

This model has several weaknesses in terms of dealing with the question of school differences. Although adaptations of it have been used in major studies of school

success (cf. 7), such studies prove only to emphasize three weaknesses of the model. In the first place, a very small proportion-probably less than one percent--of all school districts in the United States have a sufficient number of schools, even at the elementary level, to serve as the basis for a meaningful regression equation. Second, considerable information may be lost or distorted by working with averages of all variables for a school (cf. 15,9). Furthermore, the model does not lend itself to a statistical test of real differences between school performances. Its advantages, of course are obvious--the regression approach has wide generalizability to different schools and different settings, and it incorporates the effects of background variables on performance.

The purpose of the present study is to apply an adaptation of the Dyer model to data from individual students in a small number of schools, seeking an answer to the question: Which, if any of these schools is performing significantly better or significantly poorer than the others in improving the achievement of its students over time when other background variables are controlled?

The principle adaptations of the Dyer model are 1) to use regression as an exploratory rather than a predictive technique, 2) to use individual student data rather than school averages, and 3) to include school membership as a nominal variable dummy coded in the regression analysis.

In Dyer's predictive research framework, regression analysis is used chiefly because it permits the development of an equation which can be used for the prediction of a

dependent variable. The independent variables are significant only in that appropriate ones must be included, and that the linear relationship between them and the dependent variable must be established. Major effort focuses on computing the SEIs and analyzing differences between pairs of schools.

The strength of the explanatory framework, on the other hand, is on the explanation of variation in dependent variables by using information from one or more independent variables. The primary emphasis is on formulating and testing explanatory schemes to determine the relative importance of independent variables (5). In this model, the most frequently used criteria for the importance of a variable is its relative contribution to variance accounted for in the dependent variable. For the current study, this is equivalent to asking the question: Does knowledge of the school which a child has attended improve significantly the "explained" portion of achievement variance after other pertinent background variables have been controlled?

METHOD

Data for this study were collected from a cohort of 1,255 seventh grade students from all four middle schools in a medium-sized suburban community. Variables included Iowa Tests of Basic Skill scores in vocabulary, reading, work study and mathematics at both the fifth and seventh grade. (The problems inherent in using grade equivalent scores on standardized achievement tests are acknowledged [14,8]. However, these still serve as the only comparable source of longitudinal data in most schools.) Background

data were available on sex, aptitude (Cognitive Abilites Test), self-reported occupation and education for both father and mother, and the school which the child attended. Father's and mother's occupations were coded on a scale of one to seven according to the Hollingshead Social Class Scale. The parents' occupation and education measures and several alternative combinations of them were intercorrelated to test their explanatory power. It was determined by stepwise multiple regression that father's occupation alone contributed as much or more explanatory power as any of the others or their combinations; therefore, father's occupation was used as the sole measure of SES. Complete data sets of achievement scores and background information were available for 319 seventh grade students.

Similar data were also available for a cohort of 1308 sixth grade students at these same middle schools with achievement scores for tests taken in fourth and sixth grades. After listwise deletion of incomplete data cases 322 complete sets remained for this grade level. Observed means and standard deviations for each cohort, by school are presented in Table 1.

Stepwise multiple regression using the SPSS package (12) was employed to determine the relative predictive significance of each of the four proposed covariates (and, by revealing a significant overall multiple correlation coefficient, to establish the linear relationship of the variables). The data had initially been examined for conformation to a normal distribution and a general appearance of similar within-school variance which would not violate the assumptions of the F and t statistics to be applied.

Although the Pearson product-moment correlations of the covariates with the achievement scores were generally high (Table 2)--with the exception of sex--and statistically different from zero, a stepwise regression analysis with all variables entered found the contributions to explained achievement variance by socioeconomic status and sex were included in the information from Previous Achievement and Aptitude. Therefore it was sufficient to include only two of the proposed four covariates in the explanatory model.

Other previous measurements of the achievement in these middle schools suggested that one particular school had a consistently different performance pattern than the other three. Therefore, the Multivariance program (3), was utilized to test a priori contrasts of the achievement score means, adjusted for the two covariates, on each of the four achievement measures (separately) for Schools 1, 2 and 4 against the mean of School 3.

Analysis of covariance by this program tested: 1) the assumption of parallelism of regression within the four dummy-coded school groups, 2) the significance of the covariates as predictors, and 3) the significance of the addition of the coded school vestors. The significant F from the addition of the "by schools" information indicated that differences existed in the schools' contribution (Table 3).

Contrasts of the means, adjusted for two covariates--Previous Achievement and Aptitude--were evaluated by comparing the resulting t values (Table 4) with the critical values in a Dunnett's table (6). The conceptual unit for error rate is the collection of three comparisons; that is, a confidence

Since it was hypothesized that differences by school membership were connected with attendance at the school for a period of time, it seemed to follow logically that these effects should therefore be absent in students who had been in the schools a very short time. Attendance at these middle schools begins in the sixth grade--the cohort of sixth graders had been going to those schools approximately six weeks before the achievement tests were administered. Therefore the sixth grade data were submitted to the same procedure of analysis described previously for the seventh grade data with the intention of establishing a "base" for the effects of different school attendance.

RESULTS

The parallelism of regression requirement was met by all four dependent variables for the seventh grade data. Vocabulary achievement in the sixth grade data failed this test and was eliminated from the analysis. The covariates accounted for 63.5% of the variance in Math, 69.5% in Reading, 73% in Workstudy, and 68.1% in Vocabulary. The addition of the coded school vectors added 1.5% to the explained Math variance, 1% to Reading, 2.3% to Workstudy, and 1.9% to Vocabulary in the seventh grade cases. While substantively small, these additions were highly significant ($p<.01$) with F values of 3.48 (this test for Math was significant at $p<.025$), 4.13, 7.26 and 5.89, respectively.

Within the sixth grade data the covariates of Previous Achievement and IQ accounted for 68.5% of the variance in

Math, 68.3% in Reading and 71.0% in Workstudy. The coded school vectors added 0.6% to Math, 0.7% to Reading and 0.3% to Workstudy. The F statistics for these differences were 2.94, 3.03 and 1.87, respectively. Math and Reading were significant at $p<.05$.

The previously described tests established that differences existed between the effects of the individual schools. The comparisons of the adjusted means (Table 4) revealed that at the Seventh grade level each of the other three schools were significantly lower than School 3 in Reading and in Workstudy skills. Schools 2 and 4 were lower in Vocabulary and only School 1 was lower in Mathematics.

The only revealed differences in the sixth grade data were that School 2 was lower than School 3 in Reading, Mathematics and Workstudy.

The findings discussed are based on a sample of 319 seventh grade students from the cohort of 1255. The sample size was shrunken primarily by the requirement of information on father's occupation. After it was established that this covariate did not provide additional information, one analysis was rerun on the data set for Workstudy skills. By not requiring the data on father's occupation the N increased to 855. The results of this analysis were not substantially different than those run with the N of 319. Therefore, it was decided that the smaller sample sizes were representative of both grade level populations in this district.

DISCUSSION

Significant differences at the .01 level of confidence

were located by school membership in three achievement areas of the seventh grade data and at the .025 level in the fourth achievement area. All of these differences indicate means that, after adjusting for the effects of Previous Achievement and Aptitude, were significantly lower than the control, School 3. No differences were found in the comparisons between schools in the sixth grade achievement except for School 2 which was significantly lower than School 3 but mainly at the .05 level rather than the .01 level found for it in the seventh grade by-school comparisons.

Thus the findings of the investigation suggest the following conclusion based on the hypothesis tested: School 3 appears to be doing a better job of improving the achievement of its children when Previous Achievement and other hard-to-change variables are controlled.

The adjusted grade equivalent achievement scores for School 3 averaged half a year higher than those from the other schools. In Seventh grade Reading the 1% addition to explained variance contributed by knowledge of school attended represents a mean achievement level four months higher at School 3 than at the other schools; for Workstudy skills the 2.3% increase in explained variance reflects a mean advantage of five months in achievement for School 3. The additional 1.9% of variation in Vocabulary achievement explained by school membership represents a six month disadvantage from the control school for two of the schools and no difference from the control for the third.

The mathematics scores tell a somewhat different story, however. While knowledge of school attended added 1.5% to

the explained variance, this was all due to a difference of three months by one school. This leads to the interesting question: Is school 3 not doing as well in this area as in others or are Schools 2 and 4 doing relatively better in this area than in Reading, Vocabulary and Workstudy?

Overall, the evidence consistently indicated that achievement is substantially higher at School 3 than in the other middle schools in this district.

Accepting that the differences exist, to what can they be attributed? At least five plausible explanations for the achievement differences make this a difficult question to answer. Certainly there may be school instructional differences, but also, perhaps, elementary school differences, cohort differences, community and social differences unmeasured by SES, and/or interactions of all these.

Numerous school differences are revealed by the seventh grade data, whereas sixth grade data show an absence of any school effect except for School 2. This would seem to show that at the other three schools students start out equally capable but that after a year School 3 pulls ahead. The case may be that School 3 in itself is not doing very much different than the other middle schools but that it may have its associations with its feeder schools so smoothly worked out that when it gets these students it enhances the background they already have. Further research on this question of school differences should look at the achievement scores of eighth graders to see if the seventh grade school differences are intensified by an additional year's attendance.

The significance of the adjusted differences between School 2 and 3 at the sixth grade level lead one's attention to the elementary schools that feed this middle school--what is happening there to make the achievement of their "graduates" (after controlling for Previous Achievement and Aptitude) lower than those from all the rest of the district. The model described in this study can be moved down to locate differences in the elementary level also.

It is reasonable to expect that the sixth grade population was equivalent to the seventh grade, for both came from the same communities with nearly the same families, large sample size was used, and only one year separated the cohorts. Nevertheless, it has been suggested (1) that considerable achievement variation may exist between cohorts. Changes revealed by longitudinal studies are often attributed to the environment but in reality these may be confounded with changes in the individuals. Therefore, before the final judgment is made about a school's performance it would certainly be interesting and necessary to study the data on the middle school students sequentially. That is, one might not only look at different cohorts by school by year, but also follow several cohorts through these grades and compare the patterns of achievement variation by school.

It will undoubtedly be suggested that School 3 has higher adjusted mean achievement scores because, even though the direct effects of Aptitude and SES have been statistically controlled, the indirect effects have not. That argument is diminished by the showing of School 1 which has an equivalent profile in those areas but lower overall performance. How-

ever, once again it may be a problem within School 1 rather than a facilitator within School 3. The variance in the SES measure for School 1 is 40% larger than for School 3. These variances are statistically homogenous but in situ may be large enough to influence achievement averages. The quality of instructional efforts may be affected by coping with the sociological diversity in this school. The non-cognitive aspect of this influence also suggests that a measure of academic interests or motivation would be worthwhile testing for its additional contribution as a background variable. It may not be wise to make the assumption that in this model these influences are picked up by the Previous Achievement and Aptitude covariates, i.e, they may be school related.

SUMMARY

Utilization of the revised accountability model described in this study appears to have considerable heuristic value in rearranging data that exist in district files into patterns which point out investigative directions. Of course, the strength of the argument of school differences, as in this study, is built upon a statistical process resting on many assumptions inherent in regression analysis and analysis of covariance. Therefore, its conclusions can only make suggestions to the decision maker: the procedure only suggests an answer to the "where" question on school differences; the "why" questions hopefully can be attacked by observation, measurement and comparisons of the social and educational topography of the schools.

If the function of accountability is to be an on-going examination of the quality of educational operations, then

the procedures in this study, or improvements on them, speak directly to accountability's methodological needs.

Table 1: OBSERVED MEANS AND STANDARD DEVIATIONS

	School 1		School 2		School 3		School 4	
	X	SD	X	SD	X	SD	X	SD
Seventh Grade								
Math Posttest	7.45	1.53	7.06	1.25	7.66	1.38	7.15	1.15
Math Pretest	6.07	1.18	5.64	1.14	5.98	1.11	5.51	1.07
Reading Posttest	7.55	1.66	6.65	1.65	7.91	1.51	7.01	1.63
Reading Pretest	6.15	1.64	5.39	1.30	6.15	1.26	5.58	1.26
Vocabulary Posttest	7.69	1.68	6.47	1.89	7.85	1.45	6.63	1.76
Vocabulary Pretest	5.92	1.57	5.32	1.44	6.06	1.18	5.47	1.26
Work/Study Posttest	7.47	1.88	6.71	1.62	7.72	1.55	6.83	1.49
Work/Study Pretest	6.20	1.22	5.59	1.31	5.95	1.18	5.64	1.07
Aptitude	105.4	12.53	99.2	17.72	105.0	13.19	100.6	12.81
Sex	1.51	.50	1.49	.50	1.55	.50	1.60	.50
Father's Occupation**	3.81	2.55	5.15	1.91	3.89	2.16	4.78	1.92
	N=88		N=72		N=92		N=67	
Sixth Grade								
Math Posttest	6.84	1.40	5.89	1.20	6.72	1.36	6.34	1.40
Math Pretest	4.92	.96	4.47	1.09	4.82	1.08	4.64	1.12
Reading Posttest	6.90	1.53	5.69	1.40	6.75	1.53	6.34	1.60
Reading Pretest	5.24	1.38	4.27	1.31	5.03	1.35	4.80	1.53
Vocabulary Posttest	6.92	1.60	5.69	1.47	6.68	1.61	7.08	2.04
Vocabulary Pretest	5.12	1.44	4.35	1.19	4.91	1.35	3.96	2.12
Work/Study Posttest	6.91	1.64	5.71	1.53	6.80	1.69	6.58	1.70
Work/Study Pretest	5.07	1.07	4.34	1.01	4.95	1.16	4.87	1.24
Aptitude	110.6	13.39	103.1	14.28	108.1	12.09	106.5	13.41
Sex	1.49	.50	1.53	.50	1.51	.50	1.55	.50
Father's Occupation**	3.28	2.16	4.94	1.80	3.77	1.82	4.57	1.79
	N=76		N=68		N=88		N=91	

* 1=male, 2=female
** 1=high, 7=low

Table 2: INTERCORRELATIONS AMONG VARIABLES

Seventh Grade

	Math Pretest	Reading Posttest	Reading Pretest	Vocabulary Posttest	Vocabulary Pretest	Workstudy Posttest	Workstudy Pretest	Aptitude	Sex	Father's Occupation
Math Posttest	0.783	0.730	0.668	0.671	0.672	0.828	0.746	0.547	0.015	0.280
Math Pretest		0.688	0.711	0.669	0.676	0.810	0.816	0.558	0.014	0.276
Reading Posttest			0.824	0.821	0.784	0.789	0.750	0.507	-0.078	0.271
Reading Pretest				0.792	0.818	0.766	0.776	0.470	-0.093	0.257
Vocabulary Posttest					0.821	0.764	0.741	0.519	-0.017	0.312
Vocabulary Pretest						0.725	0.734	0.455	-0.061	0.225
Work/Study Posttest							0.814	0.637	-0.042	0.306
Work/Study Pretest								0.504	-0.020	0.305
Aptitude									-0.009	0.218
Sex										0.022
Father's Occupation										1.000

N=319

Sixth Grade

Math Posttest	0.808	0.756	0.702	0.663	0.561	0.845	0.786	0.609	-0.003	0.372
Math Pretest		0.733	0.780	0.642	0.595	0.762	0.829	0.571	-0.007	0.345
Reading Posttest			0.811	0.777	0.657	0.798	0.785	0.544	-0.054	0.380
Reading Pretest				0.736	0.670	0.740	0.829	0.501	-0.103	0.347
Vocabulary Posttest					0.657	0.710	0.706	0.476	-0.022	0.353
Vocabulary Pretest						0.566	0.637	0.374	-0.055	0.374
Work/Study Posttest							0.816	0.640	-0.023	0.354
Work/Study Pretest								0.570	-0.042	0.340
Aptitude									0.031	0.295
Sex										-0.104
Father's Occupation										1.000

N=322

with df>300<400 at p<.01 the critical value of r = .15

Table 4: REGRESSION RESULTS

Seventh Grade

	Percentage of variance accounted for: By Aptitude and Previous Achievement	By Schools	F on Increment	Total R^2
MATHEMATICS	63.5	1.5	3.48**	65.0%
READING	69.5	1.0	4.13***	70.5
WORKSTUDY	73.0	2.3	7.26***	75.3
VOCABULARY	68.1	1.9	5.89***	70.0
			df=3,313	

Sixth Grade

MATHEMATICS	68.5	0.6	2.94*	69.1%
READING	68.3	0.7	3.03*	69.0
WORKSTUDY	71.0	0.3	1.87	71.3
			df=3,316	

* $p<.05$
** $p<.025$
*** $p<.01$

Table 4: CONTRASTS OF ADJUSTED MEANS[1]

Seventh Grade, N=319

	SCHOOL 1			SCHOOL 2			SCHOOL 4			SCHOOL 3 (control)	
	Observed mean	Adjusted mean	t	Observed mean	Adjusted mean	t	Observed mean	Adjusted mean	t	Observed mean	Adjusted mean
READING	7.6	7.2	-2.63*	6.6	7.1	-3.43**	7.0	7.3	-2.21*	7.9	7.6
MATHEMATICS	7.4	7.2	-2.43*	7.1	7.2	-1.79	7.1	7.4	-0.42	7.7	7.5
VOCABULARY	7.7	7.4	-0.33	6.5	6.9	-3.91**	6.6	6.9	-3.85**	7.9	7.5
WORKSTUDY	7.5	7.1	-2.73**	6.7	7.0	-3.09**	6.8	7.1	-2.79**	7.7	7.6

Sixth Grade, N=322

	SCHOOL 1			SCHOOL 2			SCHOOL 4			SCHOOL 3	
	Observed mean	Adjusted mean	t	Observed mean	Adjusted mean	t	Observed mean	Adjusted mean	t	Observed mean	Adjusted mean
READING	6.9	6.5	-0.58	5.7	6.2	-2.52*	6.3	6.4	-1.53	6.8	6.6
MATHEMATICS	6.8	6.6	-0.07	5.9	6.2	-3.35**	6.3	6.4	-1.68	6.7	6.6
VOCABULARY	(these data do not meet the assumptions of parallelism necessary for analysis of covariance)										
WORKSTUDY	6.9	6.6	-0.44	5.7	6.2	-2.31*	6.8	6.5	-0.66	6.8	6.6

* p<.05
** p<.01

[1]The critical values of Dunnett's t with df=4,313 or df=4,317 are 2.07 (p<.05) and 2.70 (p<.01).

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